SPONSOR: JARED BRYSON
ADVISOR: ROBIN OTT

Tractor-Trailer Bumper Design Team

TEAM MEMBERS:

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Tractor-Trailer Design Team

This is how a car looks after a 35 mph full-width crash into the rear of a Hyundai trailer with a weak underride guard.

This is a car after a 35 mph full-width crash into a Wabash trailer with a strong guard. The occupant compartment is intact.

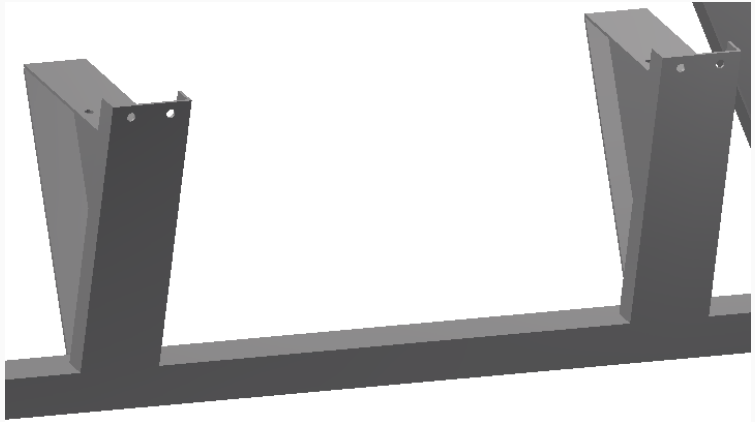
Goal is to prevent underride in all overlapping scenarios

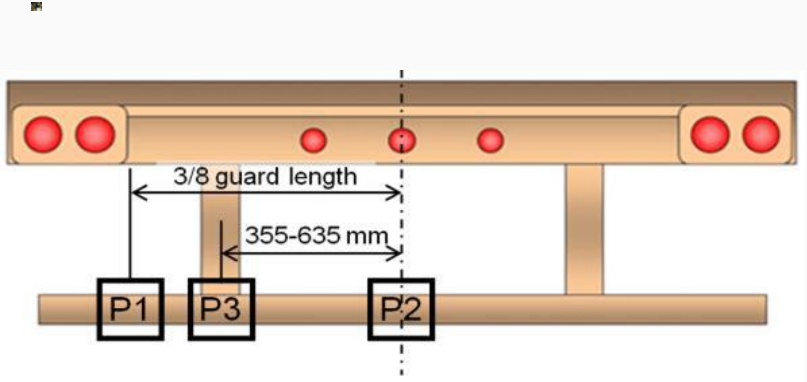
Reduce fatality rate among impacts

Specifications and Requirements

Requirement	Category	Specification	Threshold Value	Target Value	Requirements Met?
Payload shall not be affected	Design	Weight	100 kg	40 kg	Has Yet to Be Tested
Part shall meet current budget for trucking industry	Manufacturing	Production Cost	$1000 US	$500 US	One-off: no; Product with Bulk Purchasing: Yes
Part shall not corrode or react to road salt/sea air	Design	Non-Reactive	Low Grade Steel	Non-Reactive Coating & Low Grade Steel	Yes, Low Grade Steel
Part shall not require excessive assembly time for purchaser of completed trailer bumper	Manufacturing	Assembly Time	45 mins	15 mins	Has Yet to Be Tested
Part shall be applicable to several trailers with minor attachment point design variations	Functionality	Modularity	Fits 1 Trailer	Translatable to Several Trailers	Fits the Wabash Trailer
Part shall not interfere with trailer axle functionality	Functionality	% Mobility Lost	≤10 cm	0	Has Yet to Be Tested
Loading ability shall not be impeded	Functionality	Gap Between Trailer and Loading Dock	5 cm	0	Yes, 0 cm Gap with Final Design
Part shall absorb at least 20 kJ within the first 125 mm of deflection	Functionality	Damping/ Deceleration Zone	5 cm	45 cm	Yes, 18 cm Deceleration Zone at Small Overlap with Sine Beam

Detailed Design - 100% Overlap Protection





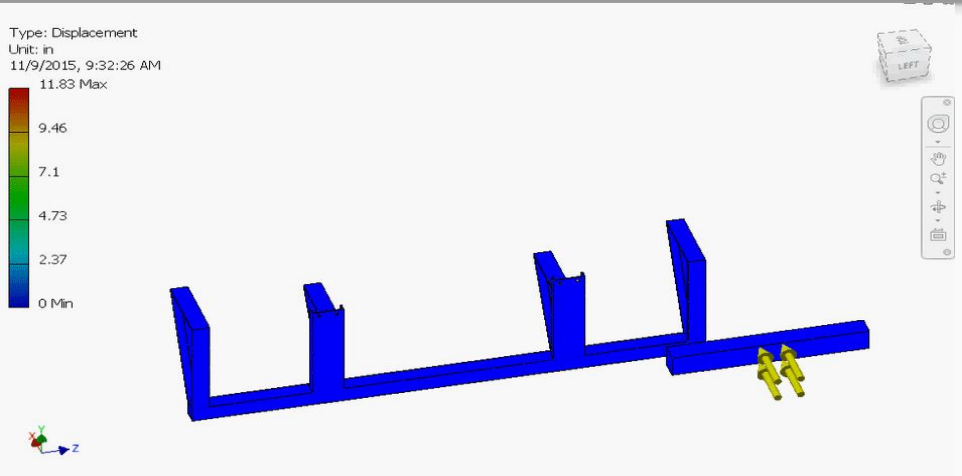
- Center supports modeled after the Wabash Bumper
- Small deflection with high strength members to allow car to absorb most of impact energy

- Wabash performed best in P3 testing
  - Highest resisting force
  - Highest energy absorption before failure

	FMVSS/CMVSS P1 peak force (kN)	FMVSS P3 peak force (kN)	FMVSS P3 energy absorbed (kJ)	CMVSS P3 peak force (kN)	CMVSS P3 energy absorbed (kJ)
Requirement	**50**	**100**	**5.6**	**175**	**10**
2007 Hyundai	109	163	13.9	135	11.8
2007 Vanguard	143*	257	14.0	209	11.8
2011 Wabash	162	287	22.1	297*	21.5*

*Test was stopped prior to 125 mm (49 mm for Vanguard, 116 mm for Wabash).

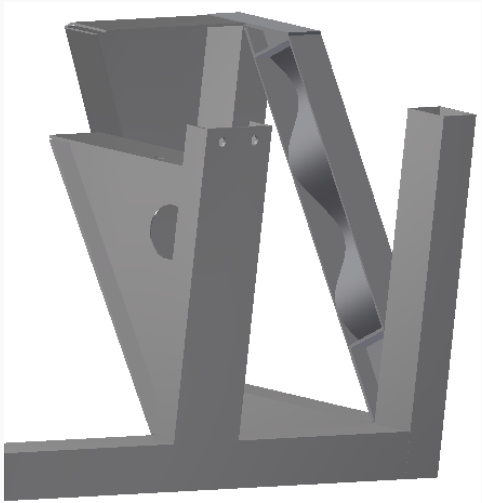
Detailed Design - 30 & 50% Overlap Protection



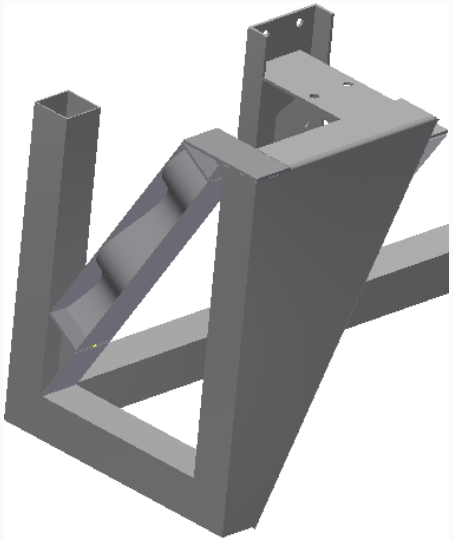
- Added vertical members to account for 30% & 50% overlap impacts
- Included Sine Beams to offer energy absorption to limit the redirection energy
  - Wanted to avoid “brick wall” approach for small overlap impacts

IIHS
Insurance Institute for Highway Safety

https://www.youtube.com/watch?v=oS7Nw_pV0K

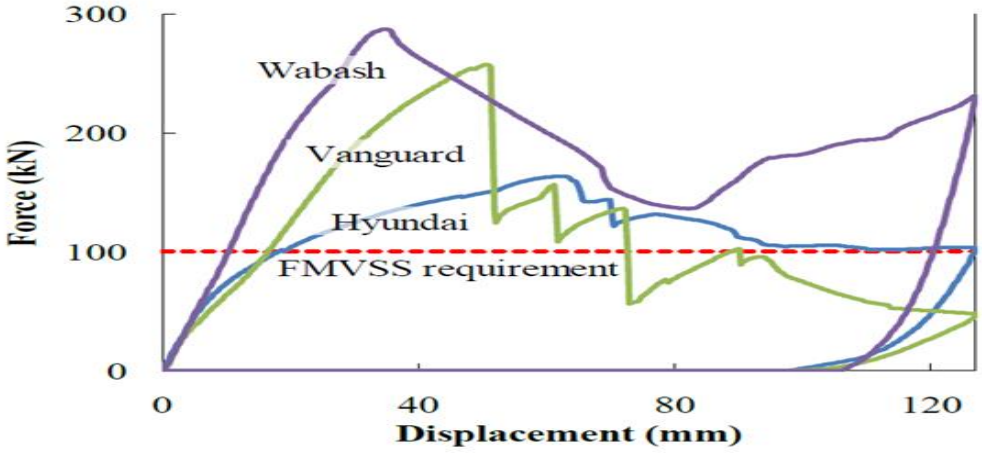


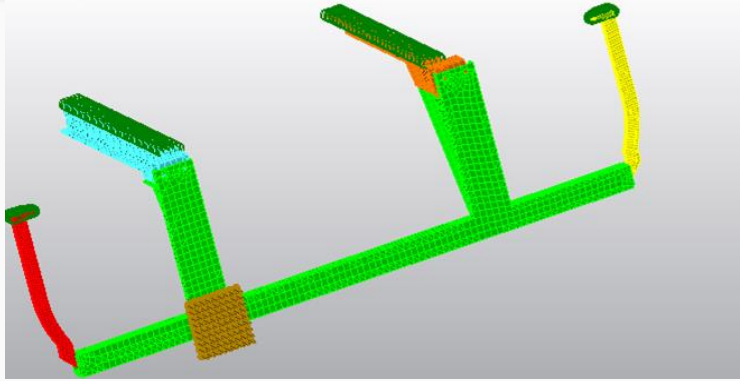
Detailed Design - Side Impact Protection

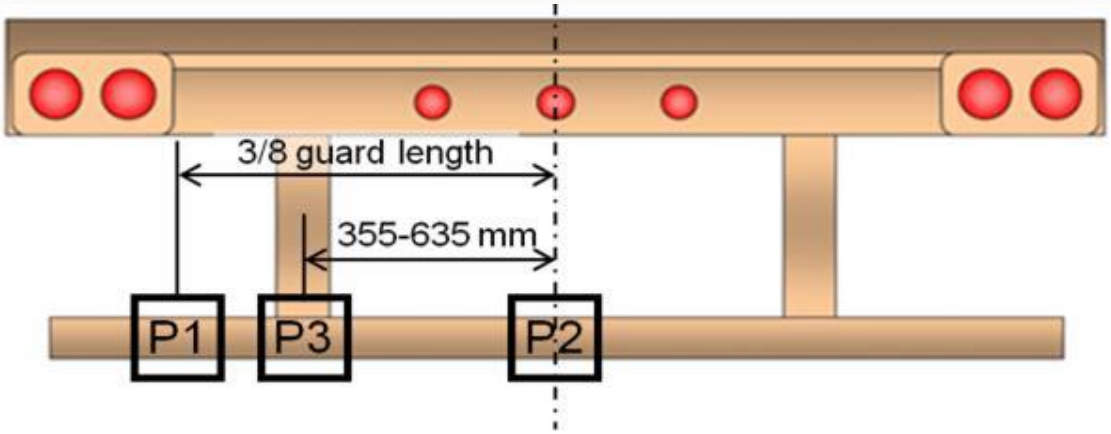


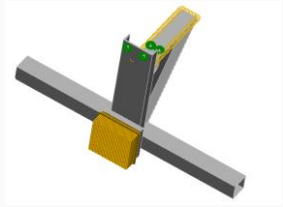
- Noticed rear impact was the only direction being protected
- Added a side, horizontal member with another vertical member to protect against off axis or side impact collisions
- Sheet metal gusset on these vertical members to provide structural integrity

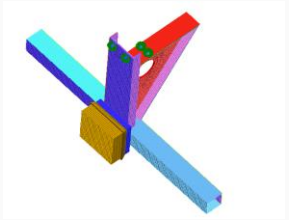
Analysis Performed Based on Test Data

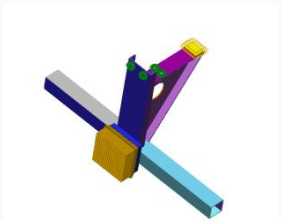


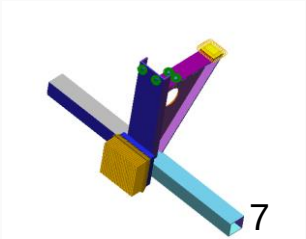




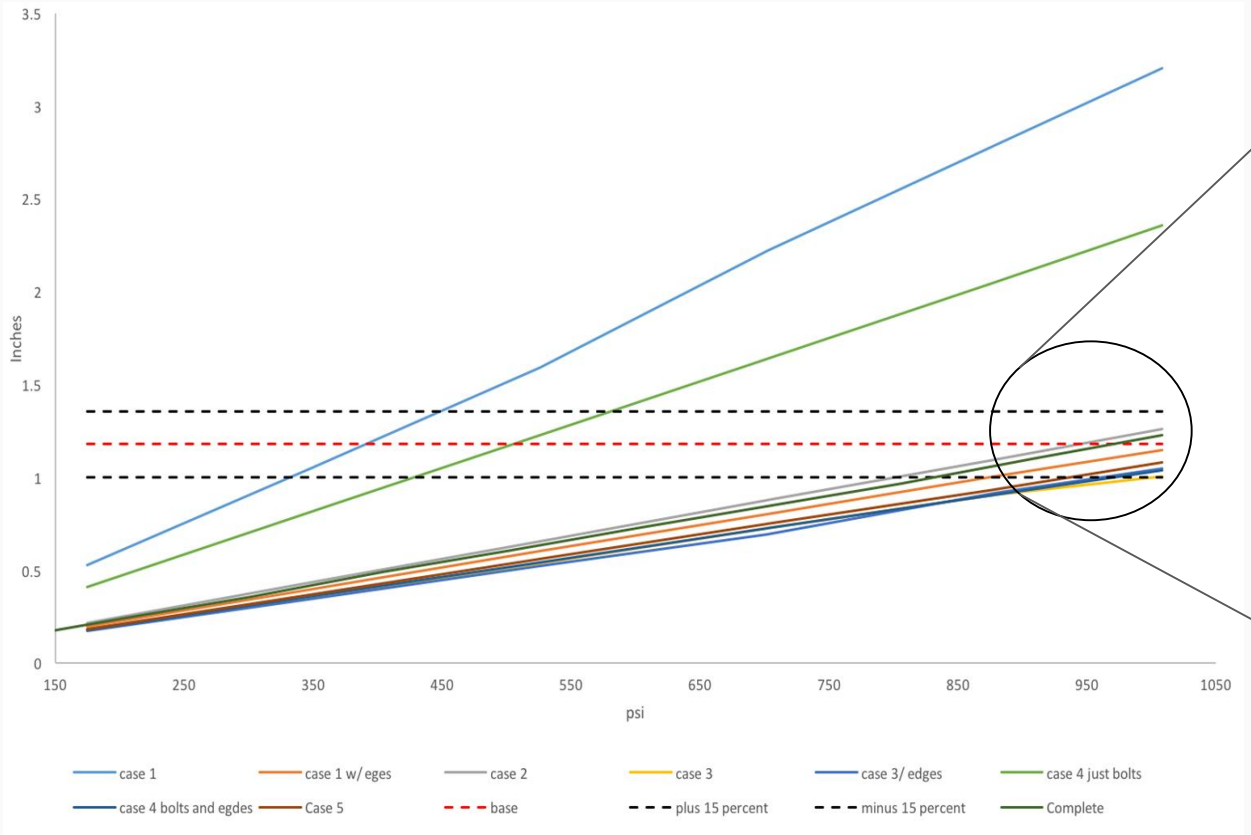


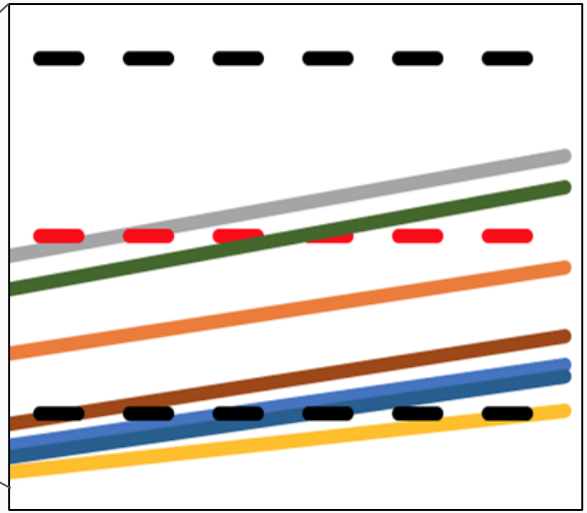




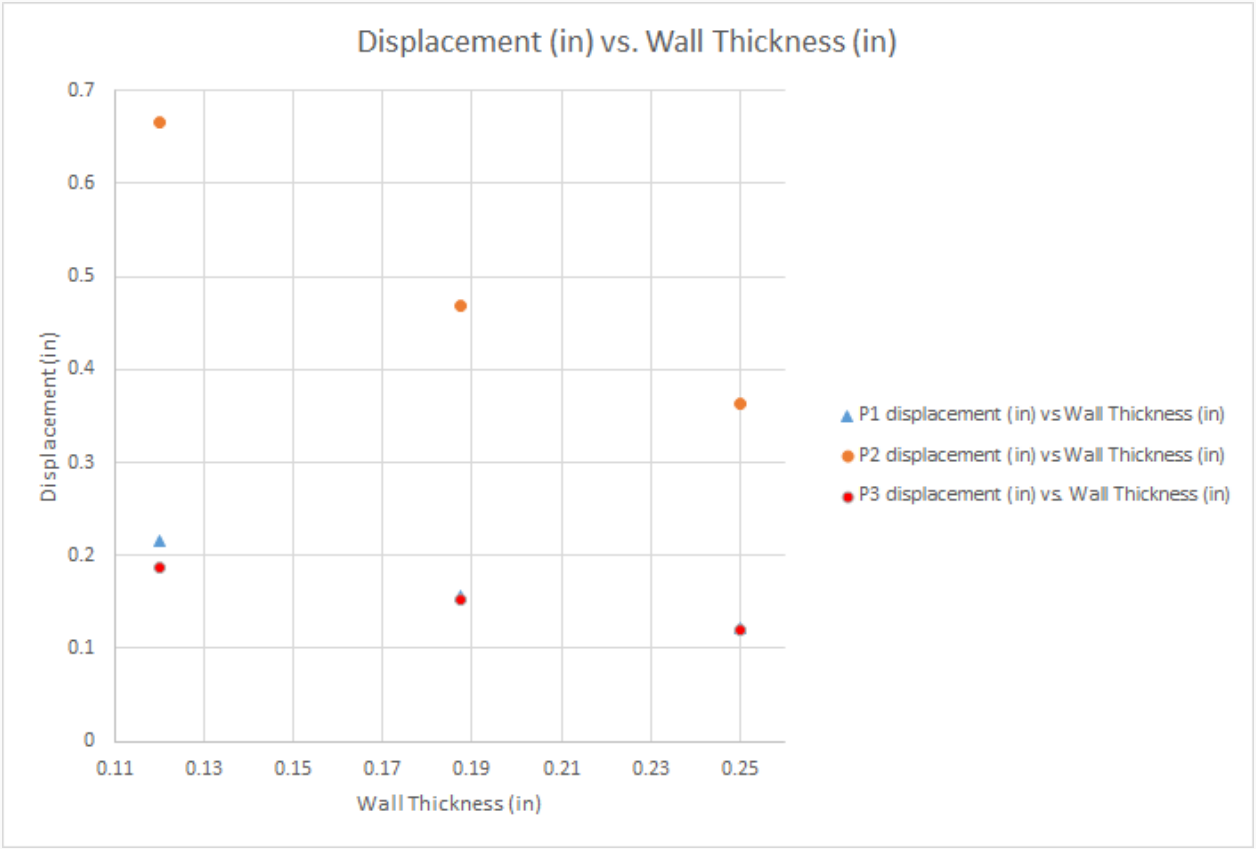


Analytical Methods: Constraint Analysis and Comparison





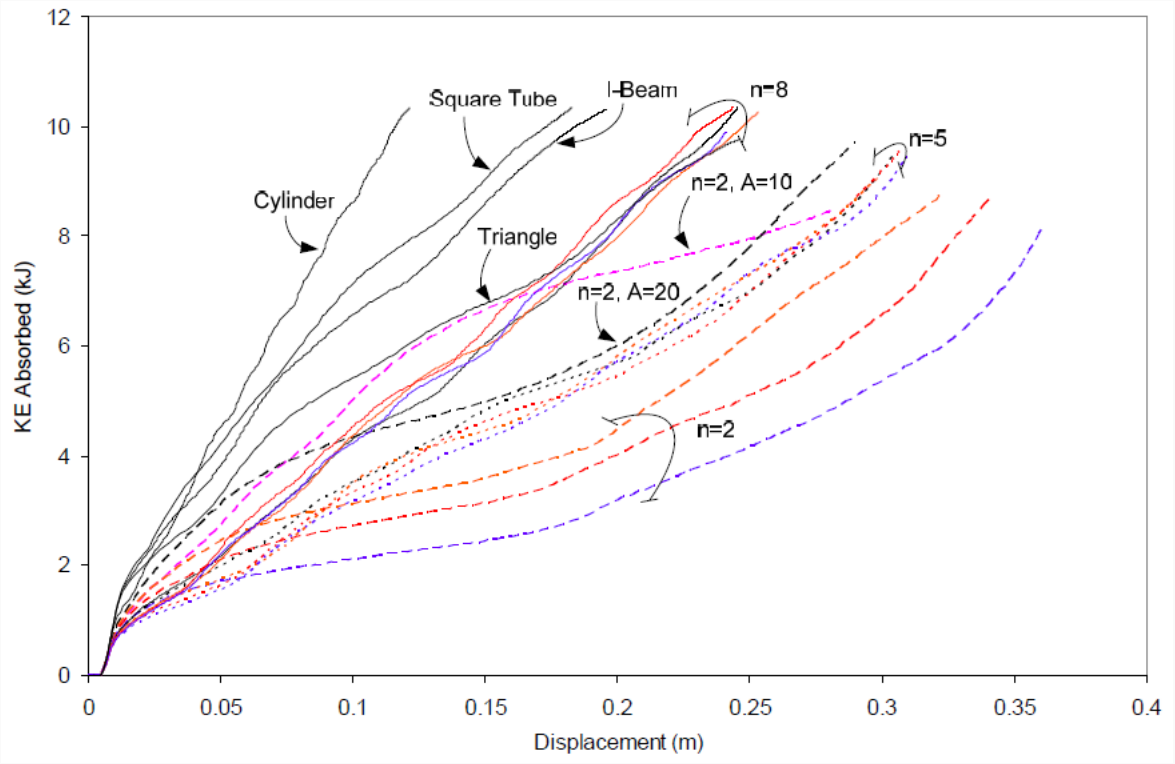
Horizontal Beam Analysis

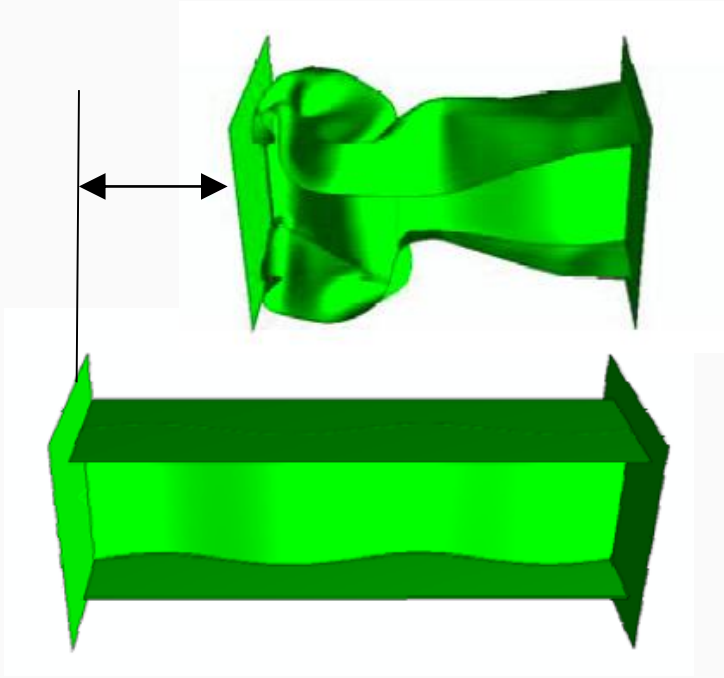


Wall thickness of ¼” show the least amount of displacement in P1, P2, and P3 locations.

We chose a different wall thickness due to the weight and cost of the material.

Why We Wanted a Sine Beam

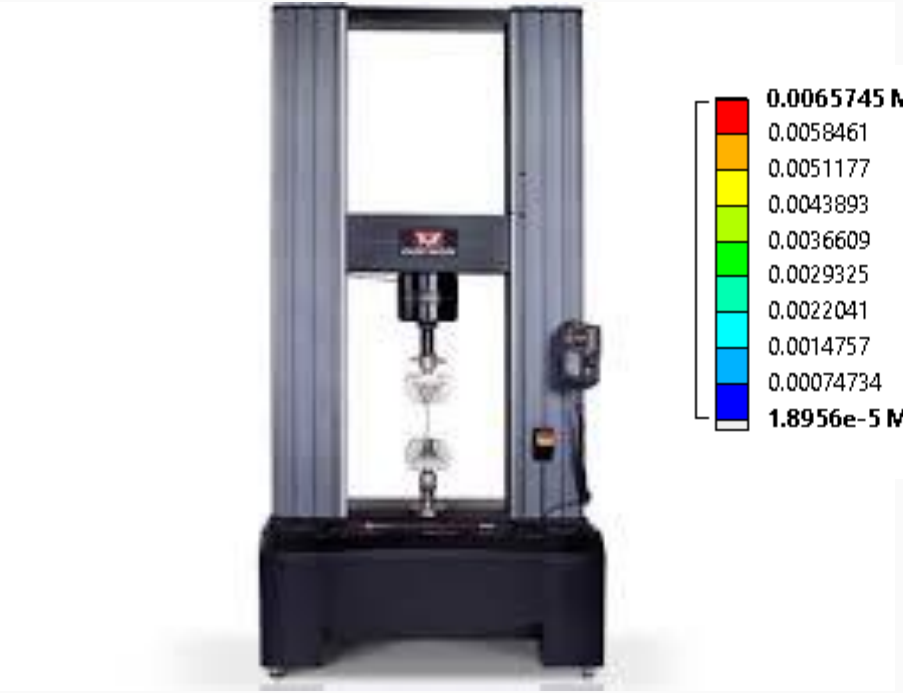


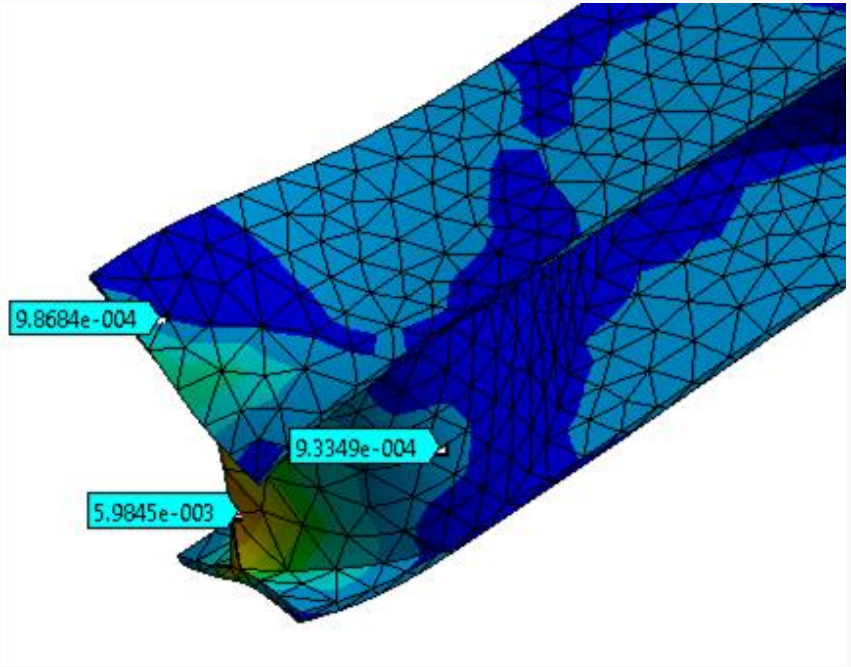


Test Plan

		Acceptance Criteria		
Requirement	**Criteria to be Tested**	**Threshold Value**	**Target Value**	**Test Plan**
Payload shall not be affected	Weight	100 kg	40 kg	Weigh Bumper on Scale
Part shall not interfere with trailer axle functionality	Mobility	<10 cm	0 cm	Measure interference on Wabash Trailer
Strain	Stress and Strain Concentration	.007	.004	Strain gages on beam then apply load
Loading ability shall not be impeded	Gap Between Trailer and Loading Dock	5 cm	0	Measure Rear Protrusion of Bumper Past Trailer Bump Stops, if any
Part shall crush as designed/intended	Damping/ Deceleration Zone	40%	70%	Crush Test on Sine Beam to Find Crush Efficiency

To Test the Strain We Will use an Instron Machine



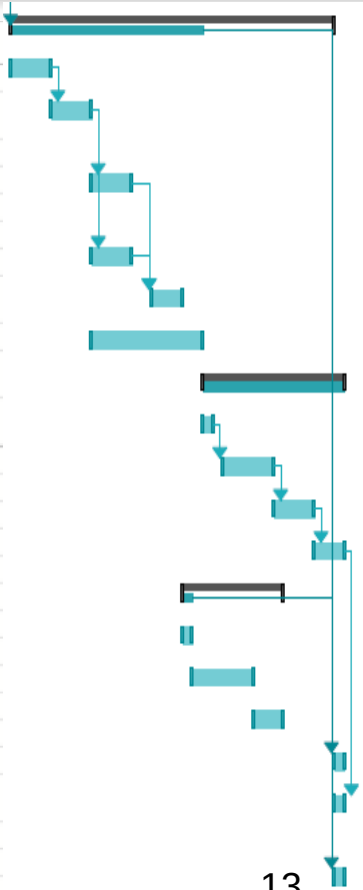


Schedule to Finish Semester

Main points for the rest of the semester are:

- Testing of Product
- Final Report
- Poster Session
- Underride Roundtable with IIHS in Charlottesville, VA
- Quad Charts

ID	Task Mode	Task Name	Duration	Start	Finish	Predecessors
45		**Product Launch Preparation**	**7 days**	**Mon 3/14/16**	**Tue 3/22/16**	
46		Work on the Powerpoint presentation	5 days	Tue 3/15/16	Mon 3/21/16	
47		Rehearse for Product Launch	1 day	Tue 3/22/16	Tue 3/22/16	
48		Product Launch (Presentation Only)	1 day	Wed 3/23/16	Wed 3/23/16	35,45
49		**Testing of Product**	**38 days**	**Tue 3/8/16**	**Thu 4/28/16**	
50		Seeking locations of testing	4 days	Tue 3/8/16	Fri 3/11/16	
51		Tour of Goodwin Lab	1 day	Fri 3/18/16	Fri 3/18/16	
52		Email Exchange with Instron Machine Technician	5 days	Mon 3/21/16	Fri 3/25/16	
53		Gathering test equipment	4 days	Mon 3/28/16	Thu 3/31/16	
54		Setup the test in accordance with procedure	2 days	Fri 4/1/16	Mon 4/4/16	53
55		Test Sine Beam Prototype in a crush test to determine crush	4 days	Tue 4/5/16	Fri 4/8/16	54
56		Document the results	4 days	Tue 4/5/16	Fri 4/8/16	54
57		Analysis of the results	3 days	Mon 4/11/16	Wed 4/13/16	55,56
58		**Final Report**	**11 days**	**Sat 4/16/16**	**Fri 4/29/16**	
59		Appoint sections to work on	1 day	Sat 4/16/16	Sat 4/16/16	
60		Work on the Final Report draft	5 days	Mon 4/18/16	Fri 4/22/16	59
61		Proofreading and Formatting	3 days	Sat 4/23/16	Tue 4/26/16	60
62		Finalizing the Report for submissio	2 days	Wed 4/27/16	Thu 4/28/16	61
63		**Poster**	**8 days**	**Thu 4/14/16**	**Sat 4/23/16**	
64		Appoint sections to work on	1 day	Thu 4/14/16	Thu 4/14/16	
65		Add information and graphics	4 days	Fri 4/15/16	Wed 4/20/16	
66		Finalize the Poster	3 days	Thu 4/21/16	Sat 4/23/16	
67		Expo and Poster Session	1 day	Fri 4/29/16	Fri 4/29/16	63
68		Final Report due in ASME conference paper format	1 day	Fri 4/29/16	Fri 4/29/16	62
69		Final Product realization demo	1 day	Fri 4/29/16	Fri 4/29/16	49
70		Trip to IIHS Conference	1 day	Thu 5/5/16	Thu 5/5/16	
71		Quad Charts	1 day	Fri 5/6/16	Fri 5/6/16	



Budget and Finances

Charges		
Sine Beam Tooling (includes cost of beams)	$	3,284.00
Parts and Welding Costs	$	2,250.00
Subtotal	**$**	**5,534.00**

Payments		
ME Department Grant	$	3,000.00
ME Department Senior Design Funds	$	1,500.00
SEC Design Team Grant	$	500.00
GoFundMe	$	125.00
Subtotal	**$**	**5,125.00**

Remaining Amount Owed	**$**	**409.00**

To account for rest of fees the ME Department has donated leftover senior design funds to our group to pay $1500 for the Sine Beam Tooling Cost.

The manufacturers of the Sine Beam predict that our idea will help shape the industry and graciously agreed to pay for the other **half** of the cost for tooling.

We are continuing fundraising opportunities to payback the Senior Design Department

Summary

In Conclusion:

- Tasked with designing a bumper to prevent underride in all overlap conditions
- Addressed not only rear but also side impact underride issues
- Test plan created to examine the remaining requirements
- Completed tractor trailer bumper manufactured and presented here today